NASA URC-Center for Advanced Nanoscale Materials (CANM)

Implementation of an Interdisciplinary Education, Outreach and Human Resource Development in Nanoscale Science for the Hispanic Community

Ileana González-González, Ph. D.
University of Puerto Rico

NASA-URC Grant Number NNX08BA48
E-mail address: carlos.cabrera2@upr.edu

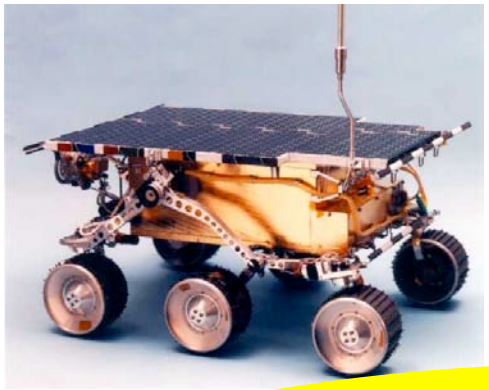
CANM Researchers

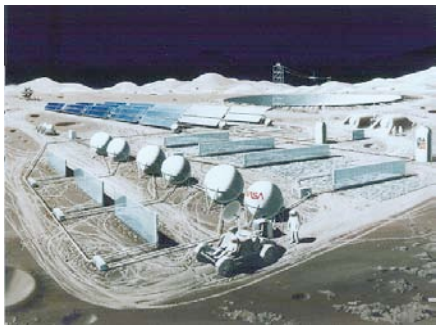
Río Piedras: Dr. Fouad Aliev, Dr. Carlos R. Cabrera (Director), Dr. Luis Fonseca, Dr. Kai Griebenow, Dr. Yasuyuki Ishikawa, Dr. Ram Katiyar, Dr. Ana-Rita Mayol, Dr. Gerardo Morell, Dr. Raphael Raptis, and Dr. Brad R. Weiner

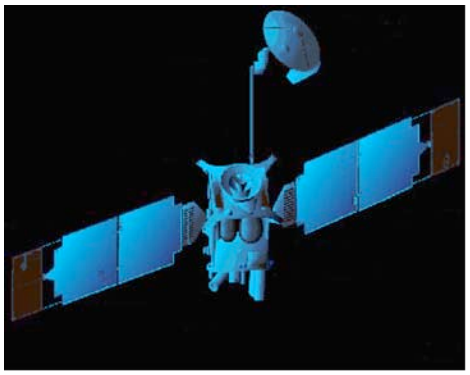
Mayagüez: Dr. Arturo Hernández-Maldonado, Dr. María Martínez-Iñesta

Cayey: Dr. Wilfredo Otaño

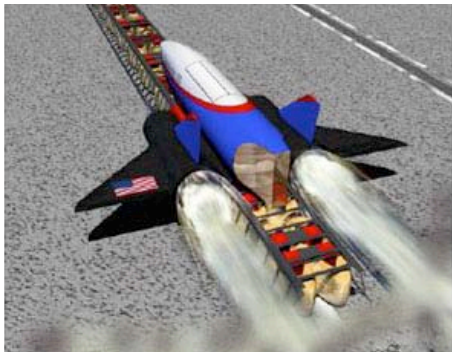
Potential Advanced Nanoscale Materials Applications







- Next generation batteries and regenerative fuel cells
- Life Support Systems
- Sensors
- Hydrogen Storage
- Lighter, stronger, and robust structures



Interdisciplinary Research Groups (IRGs)

IRG I: Life Support Systems - Develop nanoporous sorbent materials and a bioelectrochemical organic removal reactor for air and water treatment, in collaboration with NASA Ames Research Center (ARC).

IRG II: Advanced High Energy Materials - Develop nanoscale advanced high-voltage Li-ion batteries in the 5 V range and regenerative fuel cells (e.g. high pressure electrolyzers) in collaboration with NASA Glenn Research Center (GRC) and Jet Propulsion Laboratory.

IRG III: Non-Carbon Based Sensors - Develop materials that enable new robust and stable, physical and chemical sensing devices that remain operational in harsh conditions in collaboration with NASA GRC.

IRG IV: Carbon-Based Sensors and Bio-Sensors: Develop gas conductivity-based and enzymatic and DNA electrochemical sensing processes for air and water environments in collaboration with NASA ARC.

Interdisciplinary Research Group I:
Life Support Systems – Air and Water Purification

Arturo J. Hernández-Maldonado
Chemical Engineering

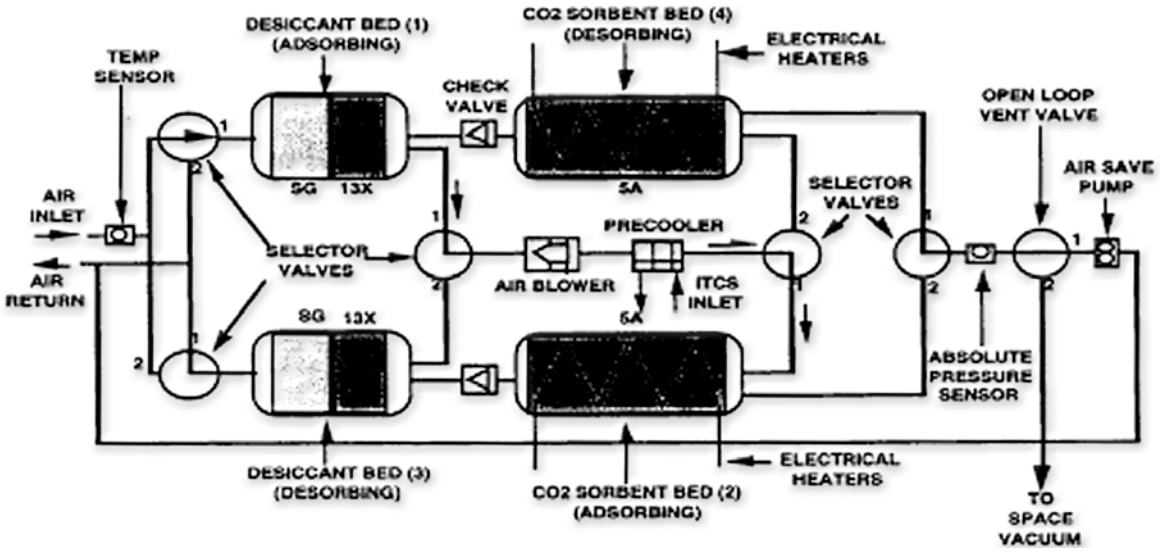
Carlos R. Cabrera, Kai Griebenow, Yasuyuki Ishikawa
Chemistry

Bernadette Luna, Michael Flynn
NASA-Ames Research Center

Sub-Theme: Selective Porous Gas Sorbents for Space Life Support Systems – A Combined Experimental and Theoretical Approach

Nanoporous Sorbents for Spacecraft Air Ultrapurification

- **Motivation:** Further reduce CO_2 concentration in spacecraft cabins and improve the efficiency of the current removal process.
- **Scope:** Bottom-up design of nanoporous sorbents to separate CO_2 from light gas mixtures at low concentration ranges (deep-purification).
- **NASA Application:**
  - –Carbon Dioxide Removal Assembly (CDRA)



  - –CDRA used in Space Station

IRG II: Advanced High Energy Materials

Cluster Leader: Ram Katiyar

F. Aliev, C. R. Cabrera, Y. Ishikawa, G. Morell, M. Pelsozy, R. Raptis, B. R. Weiner

NASA Collaborator: Michelle Manzo, GRC

IRG III: Non-Carbon Based Sensors

NASA Collaborator: G Hunter (GRC)

Research Objectives: Development of new sensors based in inorganic materials that can operate in harsh environments.

The focus: Nano- and micro-structures for sensing:

- ❑ UV radiation
  - • ZnO nanostructures (R Katiyar)
  - • Nano-Diamond films (G Morell B Weiner)
- ❑ Temperature
  - • Metal Silicides wires (L Fonseca)
- ❑ Gases
  - •Pd nanostructures (W Otaño, M Martinez)

Rationale: Nano- and micro-materials guarantee *negligible mass and minimally intrusive effects* and is beneficial for the development of multifunctional sensor designs. They show *improved crystallinity and purity and large surface to volume ratios* that can produce better responses.

Challenges: Their size can compromise their *mechanical, chemical or thermal stabilities* such that each material must be evaluated for its applicability range. The *effects of thermal treatments* on the final response of the structures must be understood in order to propose procedures to improve their use in harsh environments.

IRG IV: Carbon-based and Bio-sensors

Cluster Leader: Kai H. Griebenow

L. Fonseca, C. R. Cabrera, and. Y. Ishikawa

NASA Collaborator: M. Meyyappan and J. Li, Ames Research Center

- Scope: **(a) To develop biosensors capable of simultaneously measuring several critical physiological parameters to monitor the physical fitness of astronauts; (b) to develop carbon nanotrees as alternative electrodes to carbon nanotubes; (c) to combine carbon nanotubes and metallic nanowires with sophisticated interdigital electrode arrays to develop chemical sensor prototypes.**
- Innovation: **(a) Improved enzyme stability by glycan decoration; (b) employment of highly sophisticated carbon nanotube functionalized multiplex electronic chips.**

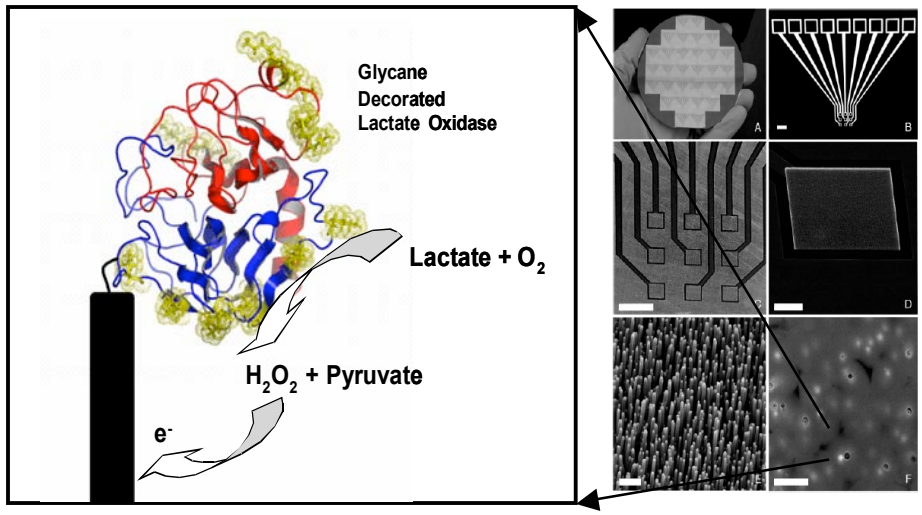
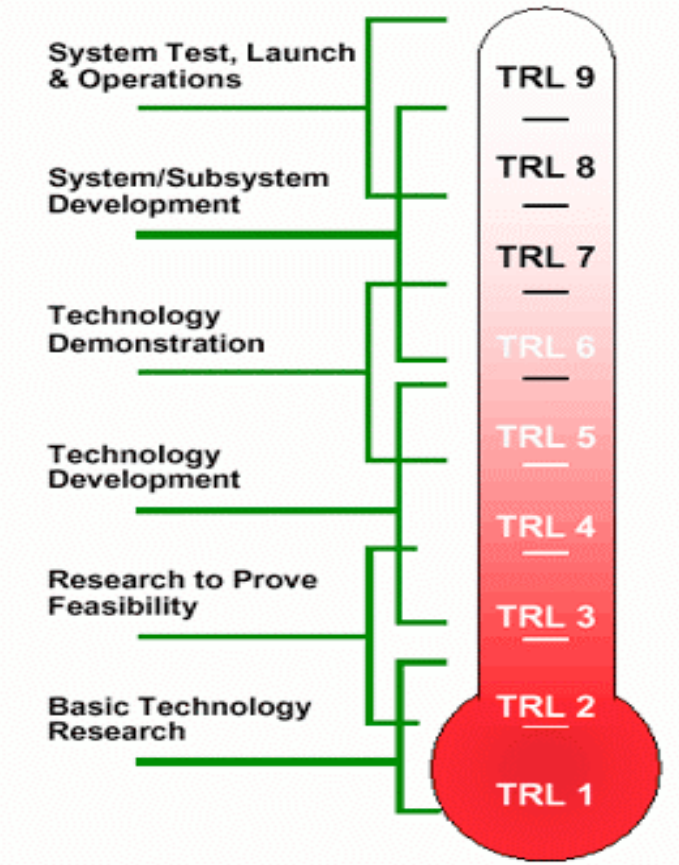


Fig. 1: Glycan-decorated lactate oxidase and other diagnostic enzymes will be immobilized on functionalized carbon nanotubes on microelectrodes integrated in miniaturized multiplex electronic chips for the rapid detection of blood physiological parameters of crew members during long duration space missions (image on the right courtesy of M. Meyyappan).

CANM Research Goals

- Innovation and Commercialization
  - will seek primarily start-up nano-technology oriented businesses interested in developing the potential new technologies created by the CANM scientists and in partnering with them.
- Enabling Technologies and Testbeds
  - it will develop testbed capacity relevant to the CANM-generated intellectual property, working with NASA centers.
- IRGs Evolving to SBIR and STTR proposals
  - with Puerto Rico Small Business & Technology Development Centers.
  - The IRGs will be strategically advanced through collaboration among NASA GRC, ARC, and JPL.



Partnerships

- CaNM will work on research projects relevant to NASA in collaboration with:
  - NASA Glenn Research Center (GRC)
  - NASA Ames Research Center (ARC)
  - Jet Propulsion Laboratory (JPL)
  - in areas that correspond primarily to the Exploration Systems Mission Directorate and secondarily to the Aeronautics Research Mission Directorate.
- Other national partners include
  - Cornell Center for Materials Research (CCMR)
  - University of Massachusetts at Amherst Center for Hierarchical Manufacturing (UMass CHM)
- At the Jurisdiction level, CANM will partner with PR NASA EPSCoR
  - PR NASA Space Grant
  - PR Institute for Functional Nanomaterials (IFN)
  - PR Small Business & Technology Development Centers (SBTDC)
  - PR Industrial Development Company (PRIDCO).

Education and Outreach Strategies

- **Use NanoSummer Camp as a model for other research programs to promote summer research activities for high school students and teachers.**
- **Train undergraduate and graduate fellows to help develop and implement in the outreach activities**
- **Encourage NASA fellows to actively collaborate with researchers at NASA Centers.**
- Expand Outreach activities to cover the Jurisdiction geographically and reach all public schools in collaboration with "Operación Exito".
- Further develop strategic partnerships with Cornell's Education/Outreach programs; and Boys and Girls Club of Puerto Rico.
- Visit schools to identify teachers and satellite schools
- Create new collaborations with NSF-funded and non profit organizations to help disseminate the outreach activities

Center for Advanced Nanoscale Materials · University of Puerto Rico

Summer Research Experiences for High School Students and Teachers at the CANM

The NASA Center for Advanced Nanoscale Materials (CANM) partnered with the American Chemical Society (ACS Seed), Institute for Functional Nanomaterials, Operacion Exito, a non-profit organization, and the Department of Energy to offer Summer Research Experiences for 35 high schools students and teachers at University of Puerto Rico Rio Piedras, Mayaguez and Cayey campuses. Participants were selected on a competitive basis. Selected students and teachers were from private and public schools from all school districts.

Workshops

Ecology Field Trip

Visit to the Nanoscopy Facility

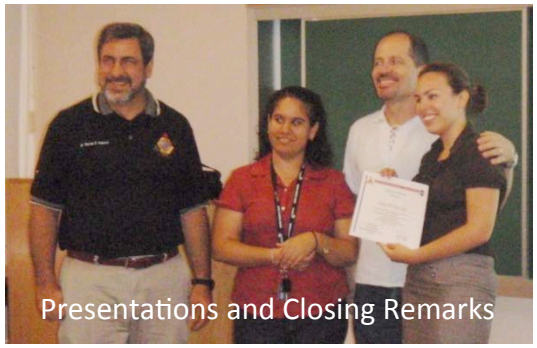
Center for Advanced Nanoscale Materials · University of Puerto Rico

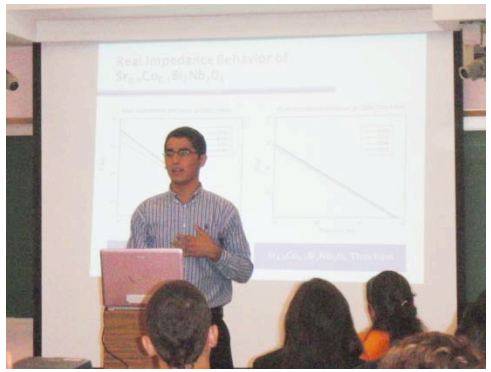
Research Activities



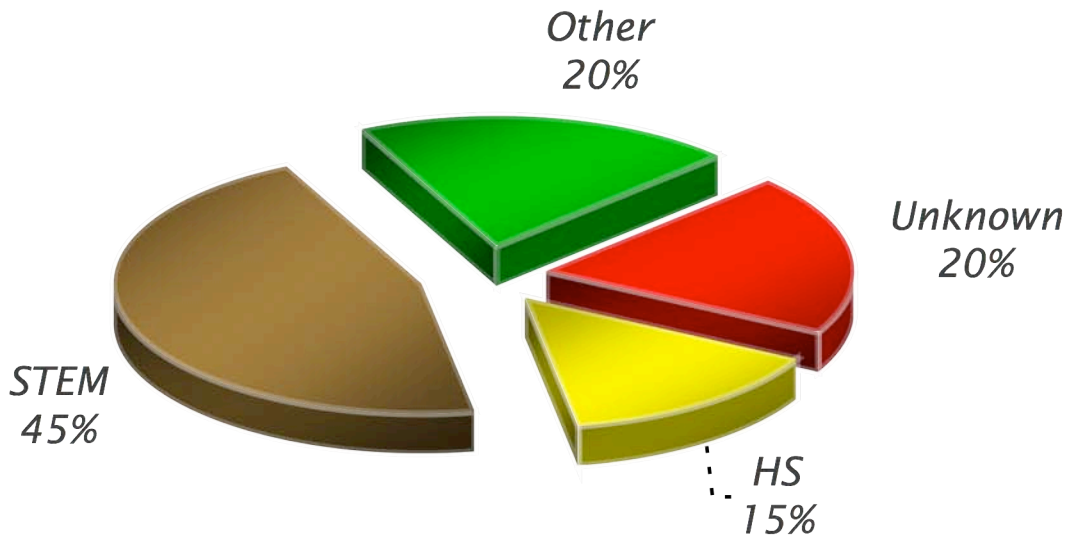


Participants developed research projects in Nanoscience Applications at an CANM laboratory. They were also trained in basic nanoscience concepts, and scientific research and communication skills; and participated in educational field trips including the Arecibo Radiotelescope. Students and teachers offered oral presentations of their research results at the end of the internships.


Presentations and Closing Remarks



Nano Summer Camp Impact



Some summer interships activities were offered jonitly with NASA Space Grant IDEAS Summer Program

One-week summer Intership: **Ten high school students and teachers from Operacion Exito developed a one week research project.**

Intensive ten-day summer Internship for Physics Teachers and students:

Four teams consisting of one physics teachers and three high school studentswill develop a research project in Physics during an intensive ten-day program.

Students from local Arecibo High Schools offered the Nanoscience Expo at the Observatory

Fuel Cells Workshop Arecibo Observatory

Dr. Gomez talks to students from Dra Conchita Cuevas High School, Gurabo at the Caguas NanoScience Expo

Students from University Gardens High School take the LED's workshop at UPR-RP

Outreach

NanoDays 2009 at Plaza Las Americas

Teachers Workshop at the Arecibo Observatory

Available Workshops 2008-2009

Workshop	Objective	Levels
Nanoscience Expo	Students will participate of interactive demonstrations, learning key concepts and applications of nanoscience and technology.	K-12
Marvelous Magnets	Introduce magnetism to young children. Explore which objects are magnetic and which are not; learn about magnetic poles and which magnets are strongest.	K-2 K-2
Light Emitting Diodes (LED's)	Students will be introduced to the electromagnetic spectra, in particular the visible region. Students will learn how a semiconductor works and its applications. Students will compare different energy efficiency of light sources.	7-12
Fuel Cell (NASA)	Connect to and build upon students' knowledge of oxidation-reduction reactions in order to introduce the chemistry involved in fuel cell technology. Students will also explore the concept of surface-to-volume ratio.	7-14
Fuel Cell Game (NASA)	Build on students' early understanding of oxidation/reduction reactions and electrochemistry. Illustrate how electrons are captured from the chemical reaction in the fuel cell.	9-14
Liquid Crystals: homemade thermometer	Students will learn basic principles of liquid crystals. They will also construct a homemade thermometer using liquid crystals.	3-6 7-9
Percolation	Students will separate soil samples using filters and analyze each fraction using microscopes. Students will use a model to measure the amount of water that passes through different size particles.	3-9
Microworlds	Students will learn the surface-to-volume ratio concept by measuring the kinetics of CO_2 nucleation in a heterogeneous process assisted by different silica particle size.	7-14

Center for Advanced Nanoscale Materials · University of Puerto Rico

NASA
UPR-RIO PIEDRAS

Station 1: Up Close


At this station participants understand the properties of different magnifying lenses.

Station 2: Fingerprint Ridges

Participants learn how experts identify differences in fingerprints using magnifying lenses

Station 3: Dots and Dollars


Participants investigate a range of images to determine how they are formed.

Station 4: Fabrics


Participants observe a variety of fabrics trough a optic microscope to determine how it was made.

Station 5: Salts


Participants observe and compare crystalline structure of various salts at different magnifications.

Station 6: Sand


Participants compare sand samples from different locations based on color, size and shape of the sand grains.

Station 7: Kitchen Powders


Participants observe the granular properties of different powders and describe them carefully.

Station 8: Small Creatures


Participants study the fascinating structures of insects, spiders, isopods and more.

Station 8: Pond Life

Participants observe different organisms that can be found in pond water.

S. Brady and C. Willard, **Microscopic Explorations**, Lawrence Hall of Science, University o f California, Berkeley, 1998.

NanoDays: April 3 – 4, 2009

A Nanoscience Exposition at Plaza Las Americas Shopping Mall : Interactive Demonstrations of key concepts and applications **offered by High School Students** of five different school from tow school districts, and **undergraduate and graduate student from NFS and NASA-funded programs** . The exposition was located at the main atrium of Plaza Las Americas, the 15th largest mall in America.

Impact: 3820 persons

2500 general public
142 students Level 10-12
97 undergraduate and graduate students
5 researchers
66 students Level 7-9
10 teachers

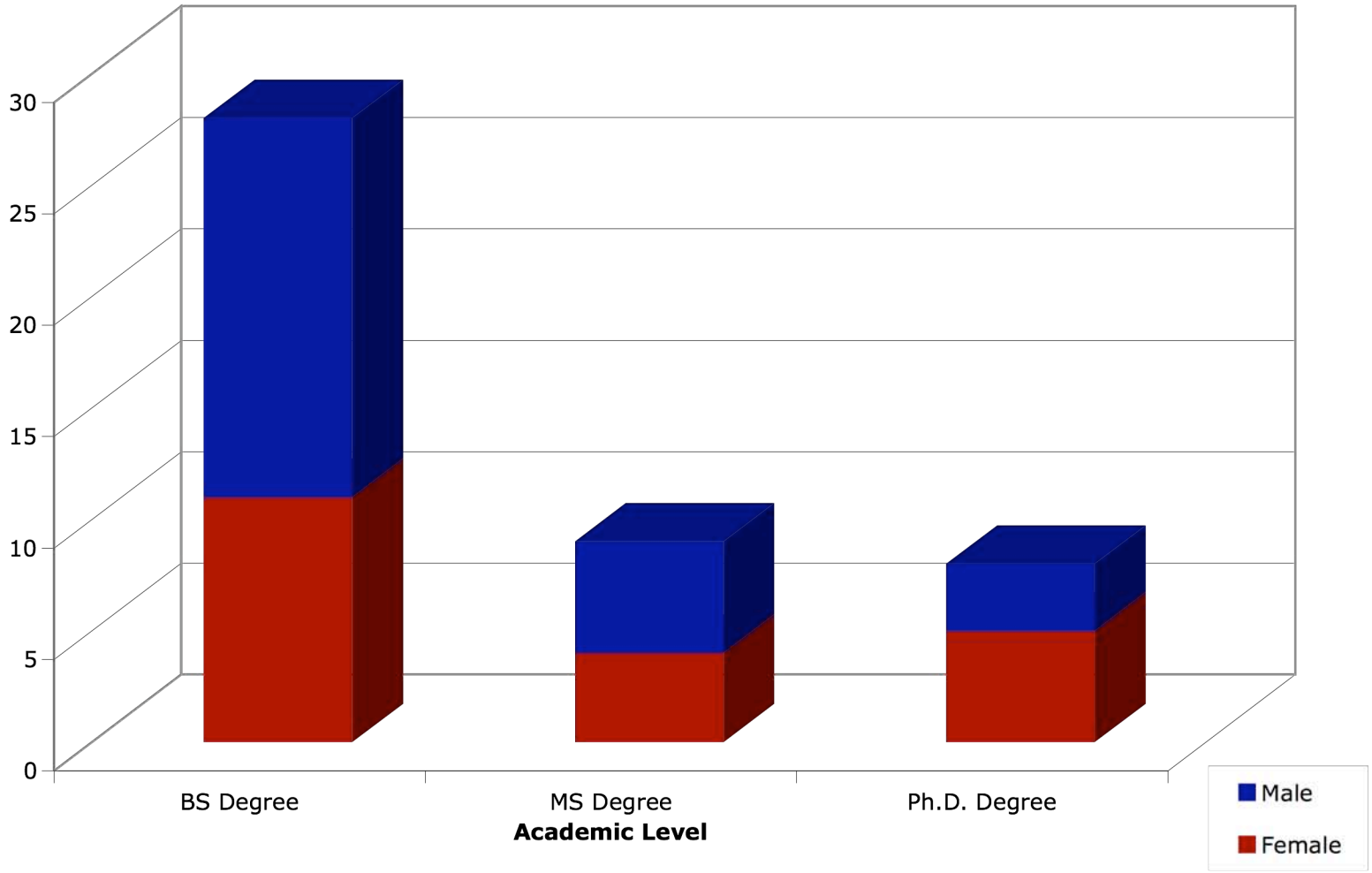
Center for Advanced Nanoscale Materials · University of Puerto Rico

Summary of Major Accomplishments

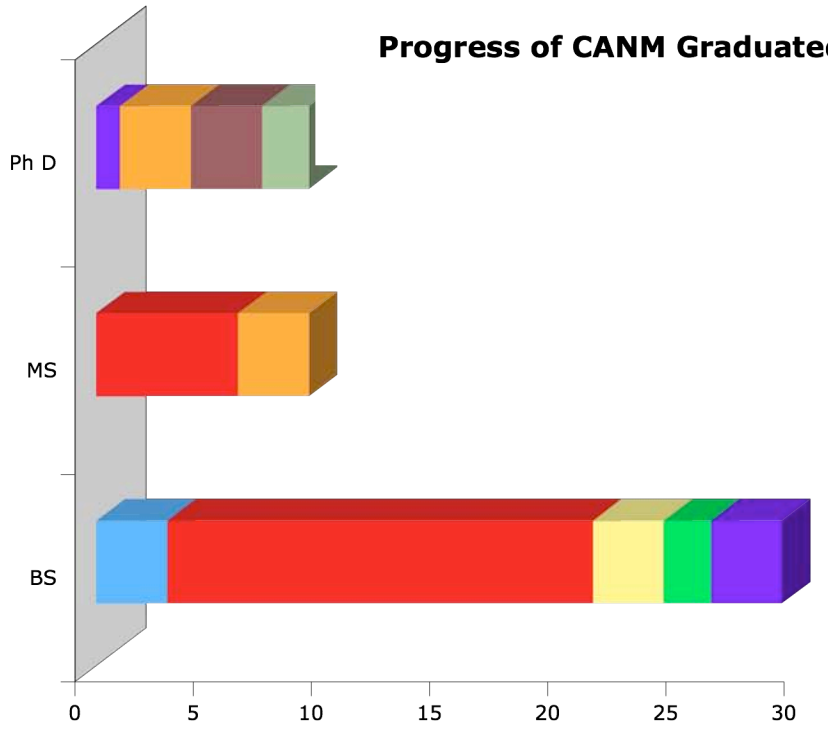
- Five new educational materials for the K-16^{+} spectrum have been created and implemented: one module and four workshops.
- Three collaborations have been established to strengthen the education and outreach program: nine of this with NSF or NASA-funded and two non-profit organizations.
- **NanoSummer Camp serve as a model to create and offer Summer Research Experiences for high school students and teachers in the Summer 2009.**
- One interdisciplinary educational proposal has been recommended for funding (G K-12) and two have been submitted.
- The number of students and teachers impacted by the Education and Outreach Team has increased five-fold (from 1062 to 5128 persons) and the number of workshops have increased three-fold (15 to 45) during this period.
- A group of teachers have been identified to be trained in the use and dissemination of IFN educational materials.

All School Districts have been impacted.

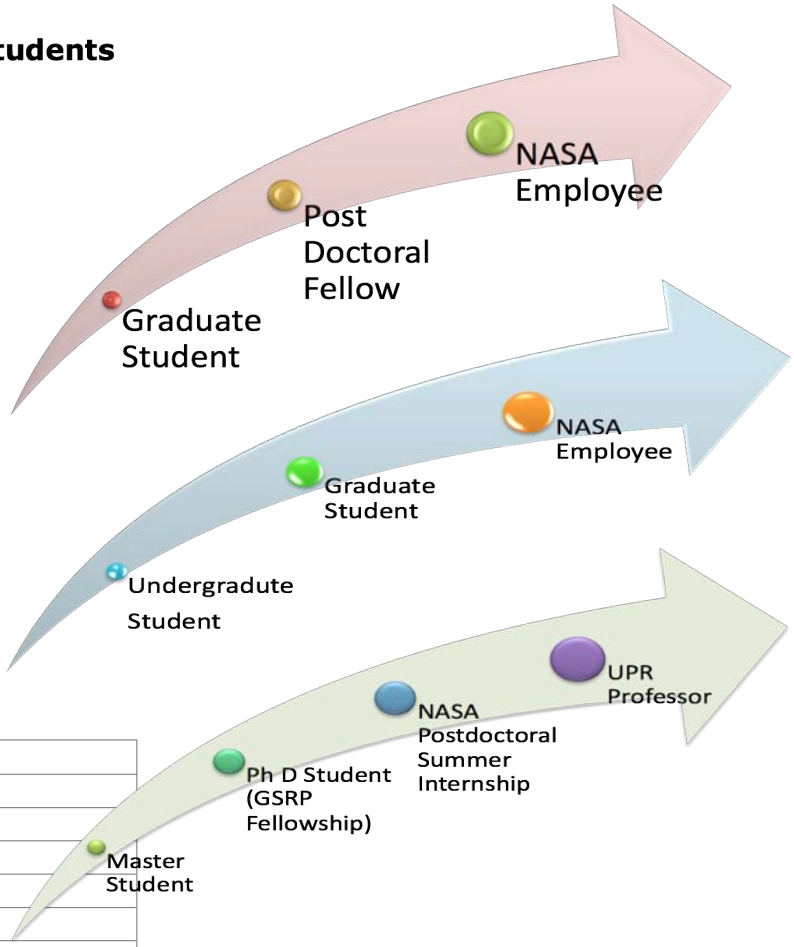
CANM students degrees



Student Accomplishments



	BS	MS	Ph D
NASA			2
PostDoc			3
Academia		3	3
Industry	3		1
ARMY	2		
Health Related	3		
STEM	18	6	
Unknown	3	0	



CANM HR Accomplishments

The CNM brought together research groups from Chemistry, Physics and Chemical Physics to work on **targeted NST research projects relevant to NASA**, in collaboration with NASA Glenn Research Center (GRC) and NASA Ames Research Center (ARC).

The major direct societal benefits of the Center for Nanoscale Materials have been the **education, training, and development of 69 different college students (29 females and 40 males) from underrepresented groups in NASA-related nanotechnology areas**, thereby enhancing the size and diversity of the national pool of qualified scientists.

CANM HR Accomplishments

A total of **30 undergraduate students** from underrepresented groups were supported, provided with quality research experiences in NASA-related projects, and carried into graduate programs in UPR and other institutions in the mainland US.

A total of **37 graduate students** from underrepresented groups were supported, their research projects were also supported, and they were either retained in graduate school or carried into doctoral programs.

Of the **7 Ph.D. graduates**, two are in academic positions, one is a founder of a start-up company, two are in postdoctoral positions, two were **hired by NASA Glenn Research Center**.

CANM HR Accomplishments

Moreover, a total of **50 high school students and five science teachers were introduced to concepts and tools of Nanotechnology** through the Nano Summer Camp organized by the CNM during the summer sessions.

Foundation that is expanding cutting-edge nanoscopy instrumentation facilities in PR for the benefit of all interested users from the academia and industry. The jurisdiction-wide Nanoscopy Facility was initiated by the CNM and is part of the legacy and institutionalization made possible by the NASA University Research Center Program.